Research Note

Sources of Error in Estimating Truck Traffic from Automatic Vehicle Classification Data

SATISH C. SHARMA
GUO XIN LIU
SCOTT THOMAS
University of Regina

ABSTRACT

Truck annual average daily traffic estimation errors resulting from sample classification counts are computed in this note under two scenarios. One scenario investigates an improper factoring procedure that may be used by highway agencies. The study results show consistent and substantial overestimates of truck traffic when truck counts are estimated using adjustment factors obtained from total traffic volume. In the second scenario, better estimates result when the required factors are obtained from a permanent automatic vehicle classifier exhibiting a pattern of truck traffic that is similar to the pattern at the sample count site. A limited research analysis of truck type estimation from sample counts is also presented in this note.

INTRODUCTION

Accurate knowledge of truck traffic has important implications for a variety of highway-related planning, design, and policy analyses (Weinblatt 1996). Estimates of truck annual average daily traffic (TAADT) and vehicle classification (VC) data for individual sections of roads are required to design pavements for the truck volume they will carry. The knowledge of what percentage of traffic is made up of trucks is also a required input for determining capacity and level-of-service provided by a road section (TRB 1994).

Only permanently employed automatic vehicle classifiers (PAVC) can provide accurate estimates of TAADT. However, limited resources available to highway agencies make it impractical to install PAVC on all sections of interest. Seasonal and short-period counts are therefore used to obtain estimates of TAADT and VC. Typically, state highway agencies carry out classification counts for a 48-hour period on weekdays. The factoring procedures currently used by various agencies for adjusting such counts to obtain TAADT estimates vary considerably and the unsophisticated factoring procedures used by many agencies can result in unsatisfactory estimation results (Weinblatt 1996).

This paper presents a number of observations regarding the temporal and spatial variations in truck traffic at several sites located in the Canadian provinces of Alberta and Saskatchewan. The main objective of this research note is to investigate TAADT estimation errors resulting from the use of inappropriate adjustment factors.

Satish C. Sharma, Professor of Engineering, University of Regina, 3737 Wascana Parkway, Regina, SK S4S 0A2 Canada. Email: Satish.Sharma@leroy.uregina.ca.

AN OVERVIEW OF THE CURRENT PRACTICE OF TAADT ESTIMATION

Weinblatt (1996) studied seasonal and day-of-week factoring to improve estimates of truck vehicle-miles traveled (VMT). In that study, he reviewed currently used procedures in the United States for estimating annual average daily traffic (AADT) by vehicle classes. He found that classification counts are typically collected for a 48-hour period on weekdays (excluding Friday evenings). These counts are then used, without any seasonal or day-of-week adjustment, as the basis for distributing estimated AADT across vehicle classes. This procedure shows that the vehicle composition of traffic does not change with time. Since AADT is usually estimated from sample counts by applying total traffic volume factors, this procedure also implies that the number of trucks can be estimated by using total traffic volume factors that might have been obtained from an automatic traffic recorder.

Weinblatt's study indicates that the above-mentioned procedure of apportioning of AADT across vehicle classes can contribute to substantial errors in VMT estimates. The study claims that significantly better estimates of VMT for all classes of trucks and of AADT for combination trucks can be developed by using modified versions of the *Traffic Monitoring Guide's* seasonal and day-of-week adjustment factors (USDOT FHWA 1995). It makes several recommendations to reduce truck AADT and VMT estimation errors through categorization of highway sections and use of appropriate seasonal and daily adjustment factors.

A number of provincial highway agencies in Canada use daily and monthly adjustment factors to estimate TAADT from short-term classification counts. These adjustment factors, however, may be derived from automatic traffic recorders reflecting total traffic variation rather than truck traffic variation. The main intent of this note is to investigate TAADT estimation errors resulting from the use of such adjustment factors.

STUDY DATA

The VC data used in this study were supplied by Saskatchewan Highways and Transportation and Alberta Transportation and Utilities. Data were collected from October 1991 to December 1993. In total, eight PAVC sites representing a variety of highway types and traffic volumes were studied—seven from Saskatchewan and one from Alberta. Locations of these sites are described in table 1. The trucks were grouped into three classes: single-unit, single-trailer, and multi-trailer.

TEMPORAL AND SPATIAL PATTERNS OF TRUCK TRAFFIC

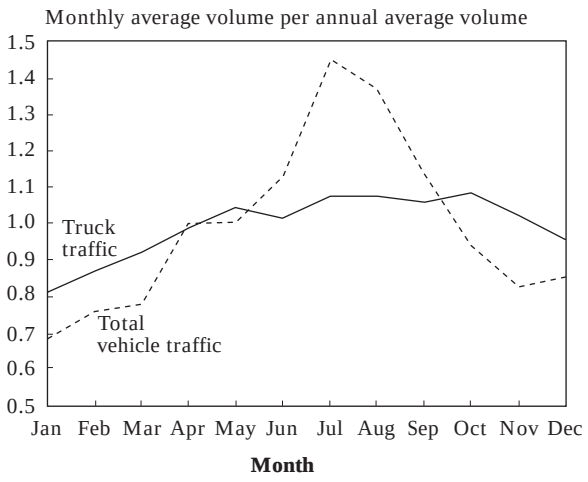
Numerous observations regarding temporal and spatial variations in truck type and truck volume were made from the study data. Figure 1 shows monthly and daily variations in truck volume at a number of study sites. Part (a) clearly indicates that there can be considerable differences between the patterns of truck traffic and total vehicle traffic. It may be noted that the y-axis in part (b) is the ratio of daily TADT (truck average daily traffic) and

TABLE 1 Location of AVC Study Sites

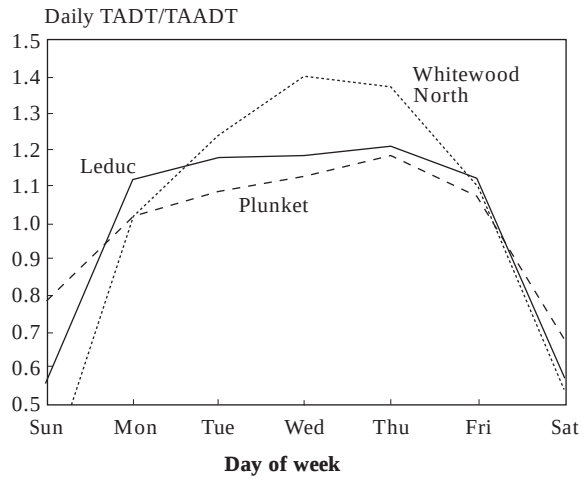
AVC site name	Location description
Indian Head	The 2 east-bound lanes on Highway 1 (the Trans-Canada highway), a 4-lane divided highway, 4.5 km west of Indian Head
Humboldt	The west-bound lane of Highway 5, a 2-lane highway, just east of Humboldt
Whitewood South	Both lanes on Highway 9, a 2-lane highway, 13.5 km north of junction with Highway 48
Whitewood North	Both lanes on Highway 9, a 2-lane highway, 7 km north of junction with Highway 1
Yorkton	The west-bound lane on highway 10, a 2-lane highway, 14.5 km south of Yorkton
Plunket	The west-bound lane on highway 16, a 2-lane highway, 12 km west of junction with Highway 20
Leduc, Alberta	The 2 north-bound lanes of a 4-lane divided highway, close to Leduc, Alberta
Regina	The 2 east-bound lanes on Highway 1 (the Trans-Canada highway), a 4-lane divided highway, just west of Regina.

FIGURE 1 Temporal Variation of Vehicle Traffic

(a) Monthly Variations of Vehicle Traffic at the Indian Head Site



(b) Daily Truck Volume Variations at Selected Study Sites



TAADT. Large variations in hourly truck traffic were also observed at all the automatic vehicle classifier (AVC) sites. Moreover, a remarkable variation in the percentage of trucks was observed during the busiest hours of operation. For example, during the 50 highest volume hours of the year at the Indian Head site, the percentage of trucks was observed to be between 3.5% and 13.5%. The average percentage of trucks over the entire year for this site was 20.5%.

The volume of truck traffic and the truck-type distribution was also found to vary spatially, i.e., from one location on the road network to another. The temporal patterns of truck traffic were observed to be considerably different from the corresponding patterns of total vehicular traffic at all the investigation sites.

ESTIMATION OF TAADT FROM 48-HOUR COUNTS

Equation 1 was used to estimate TAADT from 48-hour AVC counts:

$$\text{Estimated TAADT} = \frac{\text{STADT}}{\text{FACT}} \qquad (1)$$

where:

Estimated TAADT = estimate of truck annual average daily traffic,

STADT = average daily volume of trucksduring the sample 48-hour count, and

FACT = combined monthly and daily adjusment factor for the 48-hour period.

The sample automatic vehicle classifier data that simulated the 48-hour counts were generated from the continuously recorded vehicle classification statistics available from the permanent AVC sites. The sample counts consisted of every 48-hour period beginning at 12 p.m. (noon) on Monday, Tuesday, and Wednesday during the months of April through October.

Two scenarios were considered in this study for calculation of the adjustment factors. Scenario 1 assumed that the adjustment factors came from a permanent traffic counter reflecting total traffic variations rather than truck traffic variations. This scenario was simulated by obtaining total volume adjustment factors for the sample data from the same permanent AVC data that were used to generate the sample counts.

Scenario 2 assumed that the adjustment factors were obtained from a permanent AVC that has a pattern of truck traffic very similar to the pattern at the short-period count site. Such a scenario would occur under ideal situations where a transportation agency has a sufficient number of permanent AVCs to provide close matches to the patterns of truck traffic at the short-period count sites. Since the data were limited, this scenario was simulated by obtaining average adjustment factors for the sample data from the same permanent AVC data that were used to generate the sample counts.

Monthly and daily truck volume adjustment factors were calculated in the same manner as the volume adjustment factors were calculated for the estimation of AADT for total traffic (Gulati 1995). Estimation errors were calculated by using the following relationship:

$$\text{Error} = \frac{\text{Estimated TAADT} - \text{Actual TAADT}}{\text{Actual TAADT}} \times 100$$

Table 2 shows the mean, the standard deviation (S_e), and the range of estimation errors under Scenarios 1 and 2. As expected, the estimation errors under Scenario 1 are much larger than errors under Scenario 2. In the case of Scenario 1, the TAADT estimation errors did not follow a normal distribution, and positive mean errors indicated an overestimation of TAADT for all study sites. A careful examination of sample counts and the factors used in this scenario revealed that the positive mean error or the overestimation occurred mainly because of large differences between the traffic variation patterns for the total vehicular traffic and the truck traffic during weekdays. The weekday total volume factors used for estimation in this scenario had much smaller values (note that the factor appears in the denominator of Equation 1) than we would expect given the corresponding weekday truck volume factors that would have been used in the estimation procedure.

The standard deviation values for Scenario 2 given in table 2(b) could be used to make useful statistical statements about the estimation errors that followed a normal distribution with the mean equal to zero. For example, in the case of the Indian Head AVC site, 95% of the estimation errors would be expected to lie within ±12.15% (or ±1.96 S_e) of the mean value (which is zero).

ESTIMATION OF TRUCK-TYPE DISTRIBUTION

This study investigated the use of 48-hour AVC counts to estimate truck-type distribution. We found that there can be sizable differences between the *actual* truck-type distribution and the *estimated* truck-type distribution. For example, at the Indian Head site, where the actual average percentage of single-trailer trucks with five axles (April through October) was 34%, the 95% confidence interval of the 70 sample counts generated at this site had the lower bound of 17% and the upper bound of 51%—an interval width of 34%. A limited analysis involving frequency of counts indicated that increasing the frequency of 48-hour samples to two counts, taken at least one month apart, could reduce the estimation errors for truck-type distribution by a considerable margin. For the

TABLE 2 TAADT Estimation Errors Under Various Scenarios

(a) Scenario 1

Study site	Actual TAADT	Number of samples	Mean error (%)	Deviation (S_e) of errors (%)	Range of errors (%)
Leduc, Alberta	700	46	30.82	12.50	8.67 to 59.38
Indian Head	390	70	5.07	16.02	–32.58 to 35.87
Plunket	310	90	9.31	24.60	–33.25 to 64.29
Humboldt	170	73	17.23	21.37	–18.43 to 74.60
Whitewood North	130	65	23.43	20.12	–12.18 to 72.94
Whitewood South	100	95	33.77	30.43	–26.67 to 99.21

(b) Scenario 2

Study site	Actual TAADT	Number of samples	Mean error (%)	Deviation (S_e) of errors (%)	Range of errors (%)
Leduc, Alberta	700	46	0.0	4.0	–9.41 to 8.54
Indian Head	390	70	0.0	6.2	–14.78 to 14.17
Plunket	310	90	0.0	9.6	–26.74 to 22.64
Humboldt	170	73	0.0	11.9	–21.57 to 37.44
Whitewood North	130	65	0.0	7.7	–19.11 to 20.00
Whitewood South	100	95	0.0	7.2	–18.57 to 23.18

previous example of trucks at the Indian Head site, the width of the 95% confidence interval was reduced to 22% as compared with 34% for a single count.

CONCLUDING REMARKS

TAADT estimation errors are computed in this note under two scenarios. It is assumed in Scenario 1 that the adjustment factors come from a permanent traffic counter reflecting total traffic variation rather than truck traffic variation. The adjustment factors in Scenario 2 are assumed to have been obtained from a permanent AVC that has a pattern of truck traffic very similar to the pattern at the short-period count site. The statistical results shown in table 2 for the study sites indicate that consistent and substantial overestimates of TAADT are produced when truck counts are estimated using factors obtained from total traffic volume. The mean value (of plus and minus errors) is overestimated from 5% to 34% at the investigation sites. The width of the error interval (the difference between the highest and lowest error values, as shown in the range of errors in table 2) varies from nearly 50% to about 125% in this scenario.

In the case of Scenario 2, where appropriate adjustment factors are used, the expected width of the error interval is reduced to a large extent. In fact, when expressed in terms of the standard deviation (S_e) or the 95% confidence interval ($\pm 1.96\ S_e$), the magnitude of TAADT errors in this scenario is similar to the magnitude of AADT estimation errors for total traffic volume resulting from the Federal Highway Administration-recommended seasonal and day-of-week factoring procedures (USDOT FHWA 1995; Sharma et al. 1996).

Results of this study also indicate that the estimates of truck-type distribution from a single 48-hour count can be subject to a large margin of error. Increasing the frequency of counts to two or three in a year can be expected to reduce the error in the estimates of truck-type distribution. The effect of the frequency and duration of sample counts on the accuracy of volume and truck-type distribution remains poorly understood.

For highway capacity and level-of-service analysis, a traffic analyst requires data on the proportion of trucks in the traffic stream during the design (or peak) hour, which may be the 30th, 50th, or any other highest volume hour. The large variation of truck percentages during the highest volume hours, such as noted in this study for the Indian Head Site, may have significant implications for planning and design of highways.

ACKNOWLEDGMENTS

The authors wish to thank Saskatchewan Highways and Transportation for the data and financial assistance, and Alberta Transportation and Utilities for data provided. The authors also wish to thank Roy Chursinoff and Tom Anderson from Saskatchewan Highways and Transportation for their input into the study data and classification of truck routes.

REFERENCES

Gulati, B. 1995. Precision of AADT Estimates from Short Period Traffic Counts, unpublished Masters of Applied Science Dissertation, University of Regina, Regina, Canada.

Transportation Research Board (TRB). 1994. *Highway Capacity Manual*, 3rd edition. Washington, DC: National Research Council.

Sharma, S.C., B.M. Gulati, and S. Rizak. 1996. Statewide Traffic Volume Studies and Precision of AADT Estimates. *Journal of Transportation Engineering* 122, no. 6: 430–439.

U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA). 1995. *Traffic Monitoring Guide*, 3rd edition. Washington, DC.

Weinblatt, H. 1996. Using Seasonal and Day-of-Week Factoring To Improve Estimates of Truck Vehicle Miles Traveled. *Transportation Research Record* 1522:1–8.